MAY 1953

VOLUME 2, NUMBER 5

Battelle Technical Review

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Photographing the Invisible

PHYSICAL METALLURGIST

CHARLES S. DUMONT

Specialized materials are needed by our expanding technology to fulfill the demands made upon it. Like other fields, metallurgy must provide materials to meet the demands. The achievement of the properties required in metals, usually as alloys, is an important task of the physical metallurgist.

Alloy development is the chief technical interest of Charles S. DuMont. Since joining Battelle in 1945, he has worked on varied and specialized problems in the field. A particular interest is the effect of composition and process variables on the properties of electrical-resistivity alloys that are to be used under various service conditions. DuMont's investigations have led him into an intensive study of rare-earth alloys as well as the use of these rare-earth materials as additives to steel.

He has also worked in the field of wire technology where his knowledge of metals is invaluable. He has carried on research on wires of many types—from stainless steels to titanium—with properties varying from high strength to high electrical resistivity. His investigations have also led to research on improved techniques for producing wire.

DuMont's interest in alloys, including those of ferrotitanium, developed while he was associated with the Electrometallurgical Company. This was his first position after receiving his degree in metallurgical engineering from the University of Wisconsin. After joining Battelle, he completed the work for a master's degree at The Ohio State University in 1948. In this connection he compiled an exhaustive bibliography on titanium. Recently, this work was brought up to date and published for the Watertown Arsenal by Battelle.

For relaxation, DuMont has a number of interesting hobbies. He is a persistent and ofttimes successful hunter and fisherman. More unusual is his interest in early Japanese prints of which he has a fine collection.

Volume 2, Number 5
May 1953

BATTELLE TECHNICAL REVIEW

Dedicated to the dissemination of knowledge. Published monthly by Battelle Memorial Institute, an endowed foundation serving mankind through science and technology

Published monthly by Battelle Memorial Institute. Please address all correspondence about articles, abstracts, subscriptions and exchanges to: The Editor, Battelle Technical Review, Battelle Memorial Institute, 505 King Avenue, Columbus 1, Ohio. Acceptance under Section 34.64 P. L. & R. authorized. Printed in the U. S. A.

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Conserving our minerals is imperative since we are using them faster than we can discover new deposits. Improved beneficiation techniques can reduce the cost of extracting minerals from low-grade ores. This will make it possible to exploit large mineral deposits that are now uneconomic to use.

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The high-speed camera is no longer a laboratory curiosity. Through its use, technologists can "stop" action too fast for the human eye or slow it down so that a movement can be followed. With such cameras, technologists can study phenomena that previously were invisible.

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Revolution in Agriculture

THE WALL STREET JOURNAL tells of two brothers who bought some worn-out farmland in Missouri in 1947. The land had produced 15 bushels of corn per acre in 1946. In 1948, the new owners harvested 125 bushels of corn per acre.

The average yield of potatoes per acre in the United States was 110 bushels in 1930. Yields today average 233 bushels. In Maine, in 1948-50, the average yield was 450 bushels. The President's Materials Policy Commission predicts average yields of 500 to 700 bushels per acre in the Northwest by 1975, with production as high as 1,000 bushels an acre where irrigation is used.

Cotton in the United States averaged 287 pounds per acre in 1950. In 1930, the average yield was 157 pounds. In certain areas of California cotton runs as high as 660 pounds per acre. Regional cotton yields as high as 1500 pounds are predicted for the future.

What is happening to agriculture in the United States? How can such increases in production be explained? Only a few years ago we were worrying about depletion of soils and our ability to support increased populations at our customary living standards. Now we are producing on "worn-out" land crops that virgin soils could not begin to match. Our main problems in agriculture today are how to distribute and consume the crops we produce.

The tremendous productivity of today is, of course, just a reflection of the Technological Revolution. All of these dramatic increases in crop yields have occurred in the last 20 years. In that period we have learned how to produce and use the plant foods needed to grow luxuriant crops. We have studied crop diseases and pests and have produced chemicals to combat them. We have invented and introduced machinery that enables us to master the land and many of the vagaries of nature. And, not being satisfied with nature's offerings, we have developed vastly superior strains of plants and animals.

Each advance made on the farm has come as a result of a series of highly technical advances made in many phases of technology. The 125-bushel yield of corn achieved by the two Missouri farmers was made possible by the use of approximately one-half ton of commercial fertilizer per acre. This was made economically feasible by the fixation of atmospheric nitrogen—in turn made possible by advances in electrical power generation and transmission, turbine development, improvements in stationary boiler efficiency, and developments in chemistry and metallurgy.

The increased corn crops resulted from feeding by potash and phosphates. These became available in quantity because of a whole series of developments in mining machinery and mineral processing. The machinery used to plant, cultivate, and harvest the corn resulted from the work of design and combustion engineers and from improvements made by petroleum and rubber chemists and various other technologists. So it goes in the U. S. technological economy. Nearly every technical gain we make works deviously, but inevitably, to put more food on our tables.

The problem of food has always been a major problem to mankind. The lack of adequate food leads to many social diseases, including war. We are demonstrating in America today that the food problem can be solved. Our revolution in agriculture gives hope for the solution of many of man's century-old problems.

Clyde Williams

Director, Battelle Memorial Institute

Photographing the Invisible

by C. DAVID MILLER

The author is responsible for research on high-speed photography at Battelle where he also carries on studies in combustion of motor fuels and photographic and instrumentation problems. He has supervised the construction of cameras capable of taking up to 800,000 photographs a second. Before joining the Institute in 1947, he was associated with the National Advisory Committee for Aeronautics. In that connection, Miller developed high-speed photographic techniques and did extensive investigations on a variety of motor-fuel combustion problems.

AS MAN PROCEEDS with the technological conquest of his environment, he fashions many tools to accomplish a large variety of tasks. Among the more troublesome areas of investigation have been those in which materials and motions have been invisible to the human eye. In recent years, a number of outstanding tools have made it possible for the technologist to increase the range of his own visual powers and thus extend the possible areas of research. The light microscope, for example, magnifies the invisible. The X-ray penetrates it. The Geiger counter detects it. These instruments have brought priceless benefits to mankind in terms of better health, better products, and more efficient production processes.

Another research tool is adding a new dimension to man's conquest of the invisible. This tool is the high-speed motion-picture camera, which stops the motion that makes certain high-speed events invisible. Using this type of camera, scientists hope eventually to find answers to problems that have confronted science and industry for a long time. Used to study the causes of knock in the piston engine, the camera has already brought some valuable results. It is also being used as an aid in solving problems in ballistics, the motion of interacting machine-parts, metal-cutting processes, high-speed weaving machinery, and in the operation of jet engines.

ADVANTAGES OF THE HIGH-SPEED CAMERA

The unique advantage of the high-speed motion-picture camera is that it permits visual study of events whose development occurs too fast for the human eye to follow. Many common events take place at much more rapid speeds than we think. A band saw cutting wood moves at the rate of about 130 feet per second, or nearly 90 miles per hour. Jet fighters cover 900 to 1100 feet per second. The main stroke of a lightning discharge pierces the skies at a speed of about 33,000 feet per second. Meteors in space may travel at 130,000 feet per second. With these and hundreds of other rapid events, we can see the total motion, or end result involved. We can not, however, see the individual stages in the development of that motion or result.

Using various types of high-speed motion-picture cameras, it is possible to retard or, for practical purposes, to stop rapid events in a series of still shots. Later projection of the series of still shots at speeds the human eye can follow creates a slow-motion effect of the high-speed phenomenon. The product development engineer can then analyze "what happens" during the individual stages of the event. With this basic knowledge, he has an invaluable aid for devising methods to improve the product or process under study.

Basically, there are three types of physical changes that occur too rapidly to see with the unaided eye, but which the high-speed camera can observe with ease: first, motion of an object, such as a metal chip coming from a cutting tool or the rotation of a gear; second, the change in shape or size of an object, as for example, the distortion of an aircraft tire when it hits the runway; third, changes in the appearance of a subject, such as the light emitted when a flash bulb explodes or when a charge of gasoline burns in an automobile engine.

Many types of high-speed cameras have been developed for engineering and research. The Eastman Kodak High-Speed Camera and the Wollensak Optical Company's Fastax, however, are the only ones that are commercially available. The Eastman Kodak camera takes 16-mm. pictures at speeds up to 3000 frames per second. The Fastax, when exposing 8-mm. film, can run at rates as high as 15,000 frames per second.

Recognizing the advantage that photography at much higher speeds would have in research, Battelle

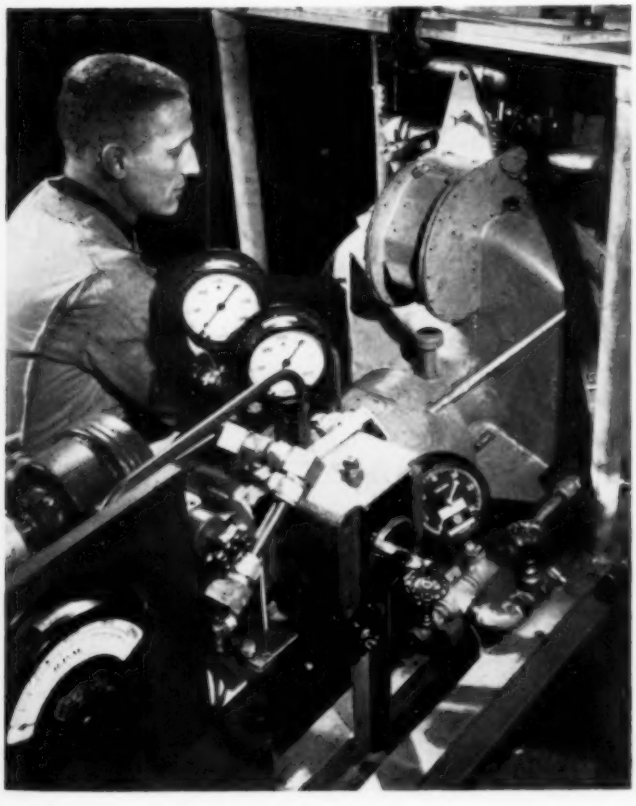
has built a camera which can be operated at speeds up to 100,000 frames per second. Faster cameras have been designed and used. Exposure durations as short as one-billionth of a second have been attained. Generally, however, as speeds go beyond 1/100,000 of a second, picture results tend to become less satisfactory. Equipment, furthermore, becomes very complex and expensive.

Uses of High-Speed Cameras

One of the most interesting uses of the high-speed camera has been for the study of fuel knock in piston engines. Fuel knock severely limits the performance of a spark-ignited piston engine. Only certain quality fuels can be used in such an engine to achieve proper performance. For decades, no definite knowledge has existed as to just what knock is.

Ten years of research by the National Advisory Committee for Aeronautics has produced some valuable results concerning the fundamental nature of knock. Photographs taken with high-speed cameras like the Battelle camera indicate that knock is essentially an explosive combustion of the last part of the gas to burn in an engine cylinder. The gas that burns explosively, rather than in the normal slow manner of the spark-ignited flame, is usually only a small percentage of the total charge. This "end gas", intimately mixed with air under high compression, usually ignites of itself and an explosive disturbance, or knock, moves through it at speeds of 4500 to 7000 feet per second. The camera captures the different stages of this phenomenon. Research on the knock problem is continuing at Battelle.

This photograph of the Battelle Isotransport Camera shows the operator placing a six-foot strip of 8 mm. film on the rotating disk. Driven by a 10 h.p. motor, the forged aluminum alloy disk rotates at speeds up to 12,000 rpm allowing the taking of pictures at rates up to 100,000 a second.



In a recent investigation, a study was made of a two-cycle, spark-ignited engine while in operation. The photography of what went on inside the cylinders was made possible by glass windows installed in the cylinder walls and heads of the engine. Through the use of the Battelle high-speed Isotransport Camera, photographs were taken of combustion, exhaust blowdown, scavenging, gas turbulence, and fuel ignition. All of these phenomena could be clearly followed in the slow-motion pictures that resulted and exact data were secured about such matters as gas and flame velocities as well as the crank angles involved.

The Bell Telephone Laboratories found the high-speed camera very helpful in the development of the best design for telephone hand sets. Many such sets were dropped onto a hard surface and broken. High-speed photographs showed that the breaks did not occur in the manner previously thought. Because of the high-speed photographic results, strength was added in places where strength was previously thought not to be needed. The development of the present hand set, with its great resistance to breakage by dropping, would have been greatly retarded without high-speed photography.

Other subjects which have been studied profitably by high-speed photography are the action of breaker points for severing electrical contacts, the operation of the mechanisms in mechanical calculators, the action of a clapper of an electric bell, fracture of metal upon impact, spray drying of solutions or emulsions, cavitation of liquids, detonation of high explosives, and ballistic phenomena.

High-speed photography may also be used effectively for studying machining operations, the spinning and manipulation of artificial fibers, chattering of brake or clutch mechanisms, the operation of typewriter parts, and the performance of breech mechanisms for guns. For given linear rates of movement, the smaller the physical dimensions of a subject the greater the need for high-speed photography in a study of the motion of the subject.

The high speed motion picture camera is no longer a laboratory curiosity. It is a vital industrial tool that is playing an increasingly important part in probing the unknown and in bringing higher standards of living.

Technology Increases Mineral Reserves

by A. C. Richardson

The author joined Battelle in 1933 where he supervises research on all phases of extractive metallurgy, ore dressing, and coal preparation. He has written numerous articles for periodicals in his fields of research and was recently co-author of a paper read before the Fourth International Congress on Industrial Heating in Paris. Earlier, Richardson had served as mining engineer with the Bureau of Mines and had investigated the coking qualities of American and foreign coals. His experience also covers coal and metal mining and open-hearth operations. He is active in the American Institute of Mining and Metallurgical Engineers.

Modern civilization depends to such a marked extent upon minerals that some writers have referred to the present as the "Age of Minerals." The aptness of this phrase becomes perfectly clear when we realize that more of the world's mineral resources have been used in the last one hundred years than in all prior time. The rapid use of mineral resources creates a serious problem for the United States. The problem is pointed up by the fact that during the past decade, newly discovered deposits have been far from sufficient to maintain mineral reserves at previous levels. Mineral deposits afford only a single harvest, and additional supplies will have to come from imports, gleaning the rejects from present operations, and by exploiting lower grade deposits.

The United States, with only about 6 per cent of the world's population and 8 per cent of its area, consumed about half the world's mineral production in 1950. Because the United States is using up its resources at such a rapid rate, the conservation of mineral supplies is particularly important here.

At the present time, there do not appear to be any new processes that will affect the mineral industry in the near future in a revolutionary way. Certainly there appears to be nothing as far-reaching as the application of flotation to fine sizes of ore or the use of heavy-media processes for the concentration of coarse sizes which were developed after 1915. We should not discount the possibility of developments of similar importance, but it seems likely that in the immediate future reductions in wastes will be accomplished by improvements in processes now in use.

Normally, a concentrator is integrated with a mine and smelter which collectively operate at a profit. For each plant there is a mineral recovery rate which is most economical. This rate cannot be profitably increased unless more efficient or less costly methods of concentration are developed. Appreciable amounts of primary minerals are lost at concentrators because it does not pay to recover them. In other cases, losses result because suitable methods have not been devised for dealing with minerals in the particular manner of their occurrence in the ores.

The waste at a given plant depends on the kind and concentrating characteristics of the ore and the type, size, and location of the operation. Recoveries of primary minerals vary from 60 to over 98 per cent. Most large-tonnage operations have primary mineral recoveries of well over 80 per cent. Although problems vary from plant to plant, most losses can be placed in one of the following categories: nonliberated minerals, slime minerals, oxide minerals in predominantly sulfide ores, soluble minerals, and minor or trace minerals.

Losses from locked minerals in sand products are usually not significant. When coarse middlings and tailings contain appreciable values, they can be crushed and re-treated at a finer size. The development of heavy-media processes and the improvements in existing methods of gravity concentration have brought increased recoveries at lower costs. Much study has been given recently to the grinding and classification of ores. The Tennessee Copper Company has recently achieved savings of from 19 to 33 per cent in power, reagents, and flotation time. This was accomplished by removing the minerals from the grinding circuit as soon as they are liberated and thus preventing wasteful overgrinding.

Problems of the Slime Fraction

Some of the highest losses at concentrators occur in the treatment of the slime fraction from the ore. This fraction may be defined as particles so fine that they do not behave as sands in usual concentrating processes but approach colloids in their behavior. Gravity, electrostatic, magnetic, and flotation processes are all inefficient in dealing with this fine material.

Some of the losses from the slime fraction are caused by over-grinding. These can be prevented by grinding the material in stages and recovering the valuable mineral as soon as it is liberated. At the Bunker Hill Concentrator, a flash grind is used ahead of the first stage of concentration. This procedure has reduced over-grinding. Increased recovery, reduced reagent consumption, improved lead-zinc separation, and increased mill capacity resulted.

Another step in the improved handling of the slime fraction is in the treatment of the slimes themselves. The Sullivan slime deck is being used to advantage to recover as by-products such valuable minerals as tin and tungsten when they occur in very small quantities in ores of other metals.

A study of the subsieve sizes of slimes has shown that fractions coarser than 1.0 micron will respond to flotation in the same manner as coarser sands if the surfaces of the valuable mineral particles are in proper condition. Technological improvements in sizing, dispersion, and flocculating reagents and the application of ion exchange in the treatment of similar-type materials may be expected to improve the recovery of minerals from slime fractions.

The Florida Pebble Phosphate Field illustrates how improvements may result from better knowledge of treating slimes. In this instance, the slime fraction will vary in weight per cent and phosphate content. However, conservative average figures would place the content at about 20 per cent by weight and 25 per cent of the total bone phosphate of lime. On the basis of these figures, we can estimate that three million tons of phosphates are lost annually. Some research work is being done on these slimes. However, they pose an extremely difficult problem because approximately 75 per cent of the slime fraction is finer than 10 microns in size.

Concentration losses in copper, lead, and zinc sulfide ores are primarily in the slimes and in the oxide found with the sulfide materials. At the Morenci Copper Concentrator in 1946, for example, sulfide copper recovery was 93 per cent while less than one-third of the oxide copper was recovered. No satisfactory method for the flotation of oxide copper is known at the present time. Nevertheless, much work is being done on this problem and substantial progress can be expected sooner or later. The practice of leaching copper ore while it is still in the ground is practiced successfully by the Miami and Inspiration Consolidated Concentrators. The same method may be applied to other ore bodies that are too low-grade to mine and process in the usual manner.

The principal losses in the concentration of lead and zinc ores are in the slimes and in the oxides found with sulfide minerals. Improvements in grinding and classification techniques can be expected to minimize such losses. Moreover, wider application of known sulfidization methods should decrease the amount of minerals lost in the oxide form. Since sulfide recoveries average about 90 per cent in modern concentrators, the addition to metal supplies from this source will not be great.

As concentration techniques are improved, tailing dumps produced decades ago are being reworked.

A sketch of a typical concentrating plant for magnetic taconites. Plants of this type may help to make almost unlimited reserves of taconites available to the steel mills, thus giving the Mesabi Iron Range a long period of usefulness.

Open cut copper mines such as this, supply the ore . . .

This results in the recovery of minerals that could not be retrieved by earlier methods. The amount of metal from this source is considerable. For example, by the end of 1946, some 3,000,000 ounces of silver, 87,000 tons of lead, and 78,000 tons of zinc had been produced from old dumps. As present concentration methods are improved, it may be expected that current tailings will also be reworked to recover valuable minerals still present.

Recovery of By-Product Minerals

One of the fields in which technology can aid in reducing waste is in the recovery of by-products materials from large tonnage operations. During 1950, 63 per cent of the molybdenum produced in the United States was recovered by flotation as a by-product of copper concentration. Most of this came from ores containing less than 0.1 per cent of the metal. At the Climax Molybdenum Concentrator, tungsten, pyrite, tin, and monazite are produced in addition to molybdenum. The mill feed contains 0.6 per cent molybdenum and only trace amounts of the other substances. At Morenci, in addition to the copper, the ores contain arsenic, antimony, lead, nickel, and cobalt in minute amounts. A careful examination of such ores could lead to numerous operations similar to that at Climax.

Beneficiation of Iron Ores

The iron ore industry is one of the best illustrations of how technology may be used to increase our mineral supplies. As our reserves of direct-shipping ores decrease, the iron and steel industry is becoming more dependent upon beneficiated materials. The intermediate, or partially altered, ores are now being concentrated by gravity methods that include logwashers, heavy-media separators, Humphrey spirals, and cyclones. In concentrators now in use, the recovery of iron varies from 50 to 80 per cent, depending on the plants and the characteristics of the ores.

Most losses occur as middlings from the coarser sizes and as liberated particles in the fines that cannot be recovered by present gravity methods. Some of these losses can be decreased by the application of available technical knowledge. For example, flotation can be applied to the fines from some of the ores, but the method requires further improvement.

Treatment of Taconites

At the present time, a major effort is being made to develop beneficiation processes for the taconites, our largest reserve of potential iron ores. The taconites are both magnetic and hematitic. In the magnetic taconite, practically all of the iron occurs as the mineral magnetite. In the hematitic taconite, the iron occurs as both hematite and magnetite. However, the magnetite is not present in sufficient quantity to make it worth recovering by straight magnetic concentration.

In both types of taconite, the iron is finely distributed through the gangue or worthless rock. A grind of 100 to 150 mesh is required for liberation. Three large pilot plants for the treatment of magnetic taconite are now under construction. They will have a combined production of over 1,000,000 tons of concentrates per year. It is expected that these plants will be enlarged gradually and others built. Eventually, the annual production of magnetic concentrates from the Mesabi Range may be about 30,000,000 tons annually.

The hematitic taconites are more difficult to treat. Flotation can be applied to some ores but more selective procedures must be developed for the major portion of the deposits. One method of treatment which seems to offer promise is to subject the hematitic taconite to a reducing roast, thereby converting the iron to a magnetic form. After that it can be ground to liberation size and concentrated with magnetic separators.

Of the other iron ore producing districts of this country, the Birmingham District offers the greatest possibility for increasing supplies by improved technology. Better concentrating techniques will augment the recoveries from both the red (hematite) and brown (limonite) ores. However, the tonnages of the ores, while appreciable, are not immense.

The largest potential reserves of the district are in the siliceous ores and in the vast tonnages of ferruginous sandstones which contain from 20 to 30 per cent iron and from 45 to 60 per cent silicon dioxide. The ores are fine grained, with iron, lime, and clay forming the binding material for the fine quartz grains.

Fine grinding is required to liberate the mineral and from 25 to 40 per cent of the concentrates are in the form of slime. To date, a really satisfactory concentrating procedure has not been developed. Combinations of gravity and flotation treatment will give concentrates containing 45 to 48 per cent of iron. Experimental work on magnetic roasting followed by magnetic separation has given better recoveries than gravity and flotation methods, but the former has not been developed to a commercial process.

Treatment of Industrial Minerals

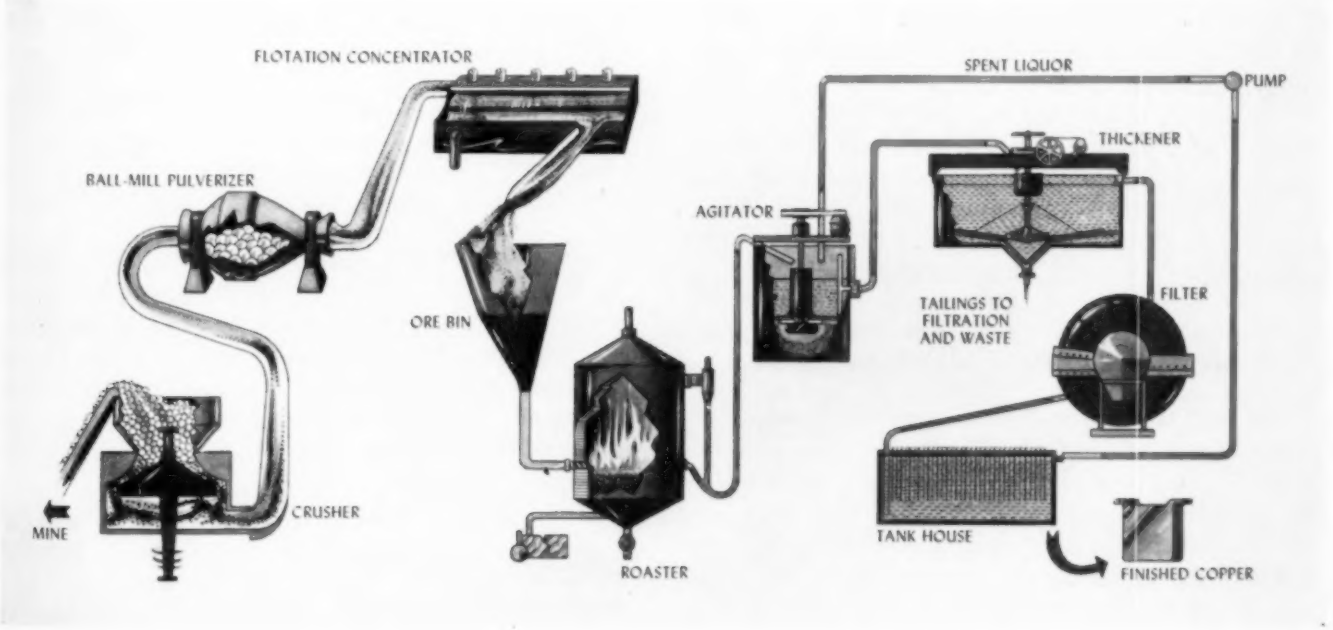
Generally speaking, beneficiation processes for industrial minerals have received less attention than the concentration of the metallics. The procedures that are successful with the metallics can also be applied to low-grade deposits of magnesite, barite, fluorspar, sodium chloride, and potassium chloride.

At the plant of the Valley Forge Cement Company, flotation is used on a low-grade limestone to remove quartz, mica, and iron oxides, thus making it a suitable raw material for portland cement. While the efficiency of this operation can be improved and lime losses reduced, the advantages to the cement industry are great. Such an operation makes selective quarrying unnecessary. Limestones which were previously considered of too low a grade may now be used. Suitable concentrating processes can be applied to other limestones. The reduction in waste can thus help in making deposits available that contain too many impurities to be marketable in their present state.

The technology of coal preparation has been developed to the point where increased recoveries of clean coal depend largely on market conditions. The United States has immense coal deposits that are developed beyond the normal needs of the country. Therefore coal is a relatively cheap commodity and, for the most part, must be cleaned to hold competitive markets. The various coal-cleaning processes are very efficient if they are selected with proper consideration for the washing characteristics of the coals. Hence, the efficiency of a plant is frequently determined by the relation of the increased preparation cost to the increased market value. Therefore, the major effort in reducing waste in coal preparation is in the reduction of preparation costs.

In general, present beneficiation techniques and procedures are capable of bringing higher recoveries of minerals than are now obtained. The failure to use currently known techniques more widely may be blamed largely upon their high cost. For this reason, it is likely that most developments, for the time being, will be concerned with cutting the costs of beneficiation. As these efforts are successful, it will be possible for us to exploit lower grade deposits of needed minerals and thus greatly increase our resources.

. . . for various recovery processes. The flow chart below illustrates a method for refining copper by electrolytic precipitation. After the concentrating and roasting of the ore, the copper is leached out and recovered in electrolytic cells.



Notes From Battelle

COLUMN CREEP IN ALUMINUM

How long will aluminum, or other metals, stand up under elevated temperatures? The constantly increasing speed of modern aircraft makes this a problem of grave concern. In many cases, stress upon heated metal in aircraft may cause deformation and even collapse of some structural parts. The usual remedy for such a condition is to overdesign parts of airframes to make certain that they are strong enough.

Research under way at Battelle for the Wright Air Development Center may show how load limits of structures can be predetermined on the basis of the temperatures to which they will be exposed. With such data available, it would probably be possible to set up design standards for alloys used in aircraft construction. This would aid in making the most efficient use of metals and at the same time assure an adequate margin of safety.

The investigation was reported by R. L. Carlson and A. D. Schwope of Battelle in a paper before the First Midwestern Conference on Solid Mechanics at the University of Illinois. The research was the first extended study of its type. The work was done to learn the behavior of 24S-T4 aluminum columns at three elevated temperatures. The columns, which had previously been stabilized to prevent metallurgical changes in the test specimens, were exposed, under axial load, to temperatures of 300 F, 350 F, and 450 F as well as room temperature. The time-failure tests ranged from approximately one-half hour to 200 hours.

The results of the investigation indicate that for a column of a given slenderness ratio and eccentricity, there appears to be a limiting load below which collapse due to creep will not occur. Carlson and Schwope conclude in their paper that this lower limit might be considered the allowable load for long service periods.

NEW SEMICONDUCTOR MATERIAL

The high cost and scarcity of germanium are a challenge to research to find cheaper and more plentiful materials that will do the same jobs now done by the metal. Semiconductors such as germanium and silicon combine the properties of conductors like copper with the insulating properties of glass. This characteristic provides a natural mechanism for detecting, transmitting, and amplifying electrical signals when semiconductors are used in transistors. Semiconductor materials can also be used for converting alternating current into direct current when used in rectifiers.

Much semiconductor research is being conducted at Battelle. Studies sponsored by the Bradley Mining Company show that aluminum antimony has electrical properties "at least as interesting as those of germanium and silicon."

Dr. Arthur E. Middleton, who directs Battelle's semiconductor research, points out that aluminum antimony has essentially the same simple, diamond-like structure as silicon and germanium, but with two kinds of atoms in its framework. This simple structure is a factor in making possible the development of methods for purifying and controlling the semiconductor materials—steps that are necessary to give the materials the desired properties.

Aluminum and antimony are much cheaper than germanium since their cost is less than 50 cents a pound as opposed to 350 dollars a pound for germanium. However, raw material cost is but a minor factor in the total cost of rectifiers and transistors. At the same time, the new material appears to have certain advantages over germanium and silicon. It may be superior where operation at high temperature is called for. Battelle's investigations of the new compound have also shown that it can act as an electric switch when exposed to light and can be used to convert light to electrical energy. These qualities suggest the possible use of aluminum antimony in photoelectric cells.

INCREASING GLASS PRODUCTION

The glass industry expanded tremendously during the first half of the 20th century. For example, in 1950 the production of containers reached 150 million gross. In 1902, production was only 10 million gross. Today, the investment in the glass container industry alone is around 400 million dollars. New developments promise continued growth for the industry in the future.

R. L. Shute and B. W. King of Battelle analyzed past growth and the possible future of the industry in their paper on "Engineering for Increased Glass Production," presented before the Spring Meeting of

the American Chemical Society in Los Angeles. The authors credited expansion in glass production to such developments as automatic machines, higher furnace temperatures, improvements in refractories, better heating conditions, and improved fabricating machines.

The authors believe that developments already in limited use will help the progress of glass production. They point out the importance of the growing adoption of combination gas and electric heating for melting furnaces. They noted that the use of the consolidated or briquetted batch may become more widespread to extend the life of costly high-production units and to permit the use of lower quality raw materials. Still other possible advances are the installation of large furnaces in less expensive, open-sided structures and the establishment of installations nearer to centers of consumption to reduce shipping costs. Shifts of location are made possible by wider gas distribution.

Shute and King see the demand for glass increasing as new products and processes are developed. They point out the growing importance of glass fiber-plastic combinations, the development of photochemical machining, and glasses for such special purposes as absorbing infrared and ultraviolet rays and slow neutrons. Still another new type of glass has been developed for shutting out intense heat. The paper points out that these and other accomplishments have been made possible through the work of ceramic engineers and chemists. These technologists, in turn, have been aided by mechanical, electrical, and metallurgical engineers as well as physicists and electronics experts.

TECHNOLOGICAL INFORMATION SERVICE

Finding out what others have previously done is the first step in every research project. But with about 60 million pages of technical material rolling off the presses annually, effective literature search is becoming more difficult each year. Estimates of the cost of literature searching place the total at from 300 to 750 million dollars annually, or from 10 to 25 per cent of the total spent on research in the nation last year.

A new technological information service, recently established at Battelle, is designed to help scientists and technologists overcome the burdensome task of tapping published knowledge. It is tailored to meet individual needs and will include such services as the preparation of bibliographies and the devising of coding and classification systems. Where required, the Institute will undertake the development of information processing equipment.

The technical information service is a natural outgrowth of Battelle's experience with literature searching problems. It has carried on such work for both industry and government. Institute activities in this field include the compiling of an extensive bibliography on titanium for the Watertown Arsenal, the development of a machine system for accepting, storing, and searching data for the Wright Air Development Center, and the preparation of a monthly review of metals literature for the American Society for Metals.

All the latest developments for the processing of information will be employed at the Institute, including standard business machine punch-card equipment, xerography, microfilming, and other pertinent electronic devices. A continuing study on methods for improving existing information-processing techniques is a part of the program.

Battelle staff members assigned to the new service include Dr. Robert C. McMaster, supervisor of electrical engineering, Dr. Iver Igelsrud, technical librarian, Roger L. Merrill, and Alvin T. Maierson.

GILLETT LECTURE PUBLISHED

The first Horace W. Gillett Memorial Lecture, "Man, Metals, and Power," has just been published. The lecture was presented before the Fiftieth Anniversary Meeting of the American Society for Testing Materials by Norman L. Mochel.

The Gillett Memorial Lecture was established jointly by ASTM and Battelle. Dr. Gillett was Battelle's first director and later Chief Technical Adviser. The annual lecture was set up to commemorate his achievements in the field of metallurgy. The subjects of the lectures are concerned with development, testing, evaluation, and application of metals—fields in which Dr. Gillett made significant contributions. Mr. Mochel knew Dr. Gillett for many years and presents many interesting sidelights on his life and work in this first lecture.

Mr. Mochel, who is Manager of Metallurgical Engineering at the Westinghouse Electric Corporation, Lester Branch, has had an outstanding career. During World War II, he made important contributions to the National Steel Specifications work and is now active in the National Advisory Committee for Aeronautics. He is vice president of the American Society for Testing Materials.

The published lecture is bound in heavy paper and includes 40 illustrations, several in color. Copies may be obtained from ASTM Headquarters at one dollar and fifty cents. The price to members is one dollar and fifteen cents.

RECENT PAPERS AND ARTICLES BY THE RESEARCH STAFF*

Boiler Tube Corrosion. A. M. Hall, D. Douglass, and J. H. Jackson. *Machinery Lloyd* (Overseas Edition), January 31, 1953.

Metal Data. Samuel L. Hoyt. Revised Edition of *Metals and Alloys Data Book*, 1952. Reinhold Publishing Corporation, New York.

Summary of Progress on Studies of Stress Relaxation in Rail Steel and of Deformational Behavior of Rails. W. S. Hyler and H. J. Grover. American Railway Engineering Association *Bulletin*, February, 1953.

Cast Alloys for Salt-Bath Heat Treating. J. H. Jackson. *Alloy Casting Bulletin*, November 1952.

Application of Standard Business Machine Punched-Card Equipment to Metallurgical Literature References. Alvin T. Maierson and W. W. Howell. *American Documentation*, January, 1953.

The Diffusion and Solubility of Nitrogen in Beta Zirconium. M. W. Mallett, E. M. Baroody, H. R. Nelson, and C. A. Papp. *Journal* of the Electrochemical Society, March, 1953.

Effects of Carbon, Oxygen, and Nitrogen on Welds in Titanium. D. C. Martin. *Welding Journal*, March, 1953.

Isotransport Camera for 100,000 Frames per Second. C. David Miller and Arthur Scharf. *Journal* of the Society of Motion Picture and Television Engineers, February, 1953.

*In most cases, reprints will be available from the Battelle Publications Office upon request.

ART OF SPECIMEN POLISHING

Polishing metal specimens for metallurgical examination is an art calling for judgment, experience, and patience. No two metals react the same to a particular abrasive or polishing cloth. Long experience is needed to judge if red rouge, alumina, diamond paste, or some other abrasive will give the desired results. Then come long patient hours at the wheel until the specimen has received the delicately exact finish sought. After polishing, the metal is chemically etched to reveal its microstructure.

BATTELLE INSTITUTE was founded by the will of Gordon Battelle as a memorial to the Battelle family. The Battelles were among the first settlers of Ohio and were prominent in the development of the state's iron and steel industry.

Gordon Battelle, last of the family line, was impressed with the benefits to be derived from industrial research and left his estate for the building and endowment of an Institute "for the purpose of education . . . the encouragement of research . . . and the making of discoveries and inventions for industry." The Institute began operations in 1929.

As established Battelle provides, on a not-for-profit basis, the physical plant, equipment, and personnel for conducting research. The great bulk of it is applied research conducted for industry and government.

In keeping with its educational function, the Institute also conducts fundamental or basic research. The results of much of this research are published for the general encouragement of science and industry, and to benefit the public welfare.

Fields of research at Battelle include agriculture and practically all the industrial and engineering sciences.

JUNE 1953
VOLUME 2, NUMBER 6